Flash flood forecasting model of Lake Managua, Nicaragua using existing meteorological observations and water level observations of Lake Managua.

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Abstract

After hurricane Mitch, October 1998, the water level of Lake Managua was so high that there was evident risk of a serious flood in some communities near the lake. There was a need for forecasts of the water level. There were no telemetric hydrological data available. So the only possibility was to use precipitation data from existing regular reporting meteorological stations and water level observations of Lake Managua. There was water level data from 1980 and precipitation observations from 1959. These statistics were used.

The first attempt was to develop a model for the rainy season to forecast monthly changes of the water level and to find a minimum amount of stations, which will be needed, for this type of forecast. The work started by calculating the balance value of monthly area mean precipitation in the cases when there was no change in the water level. When this balance value had been calculated the relation (k) between precipitation over the balance level and observed rise of the water level was calculated. It was found that two meteorological stations were enough for this purpose but for the flash flood forecast it was necessary to have observations of three meteorological stations. These three stations have been used for the monthly forecasts as well. The rise of the water level in a month is the average area precipitation over the balance level multiplied by k.

The physics of the model has been tested using observed monthly precipitation of the last rainy season (June 1999-November 1999). Correlation coefficient between values calculated by the model and observed water levels of Lake Managua was r=0.988. The only real problem is to forecast monthly mean area precipitation. To improve this statistical forecast mean average monthly precipitation was calculated for three types of months: cold (La Nina), normal and warm (El Nino) using 41 years of statistics. These average means will be used in the future. It has been known that in Nicaragua the El Nino year is dry and the La Nina year is wet. But in this study it has been found that the effect is totally different in the beginning of the rainy season (May-June) than at the end of the rainy season (August-October). This difference has not been found earlier in Nicaragua. During the calculations it was observed that in very heavy rains (in flash flood situations) almost all the precipitation enters the lake in four days. Now k is close to its natural value: the area of the water basin divided by the area of the lake. The daily forecast for the next four days based on these facts was developed.

The daily model has been tested during the most rainy period in 1999 (Sep 19 - Oct 14) using daily precipitation observations and the water level observations of Lake Managua. Correlation coefficient between the water level forecast of 24 hours by the model and observed water levels of the lake was r=0.996. The daily model has also been tested in using observations during Hurricane Mitch when the water level of Lake Managua rose almost 4 meters. Correlation coefficients between calculated values by the model and water level observations were r=0.869 for the one day forecast and r=0.794 for the two day forecast. A significant under forecasting was found after the heaviest rains. When the case was studied more carefully it was found that a neighboring river flooded over the watershed to the water base of Lake Managua. To calculate amounts of the water from the neighboring river the same philosophy as in the daily model was used to calculate corrections for the forecasts. When these corrections had been made in the forecasts correlation coefficients were r=0.997 for the one day forecast and r=0.984 for the two day forecast. Also a monthly forecast for the dry season has been developed.
All three forecasts are ready for routine use after the approval of the local authorities.